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ABSTRACT

This third in a series of eight modules for a course titled Mechanical Inspection describes all the major types of valves utilized in a nuclear power plant and the purposes of the preinstallation and installation inspections: also describes the valve testing required for particular valves. The module follows a typical format that includes the following sections: (1) introduction, (2) module prerequisites, (3) objectives, (4) notes to instructor/student, (5) subject matter, (6) materials needed, (7) procedures, (8) data table, (9) reference materials, (10) test. (The course is one of fifteen technical courses for the second year of a two-year postsecondary curriculum in Nuclear Quality Assurance/Quality Control Technology.) (LRA)

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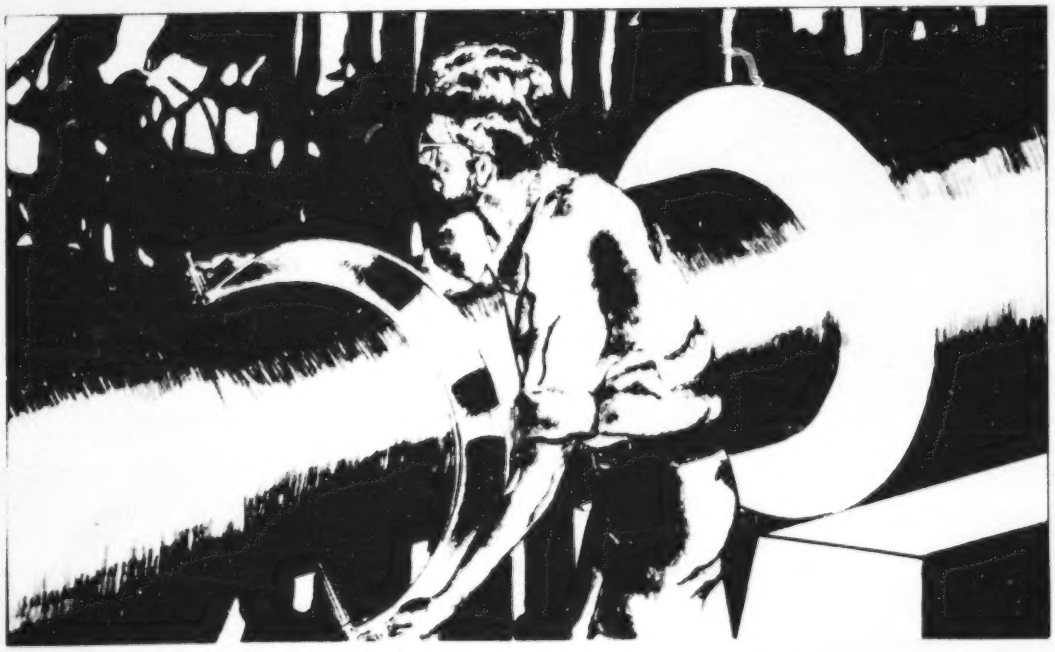
NUCLEAR TECHNOLOGY

COURSE 30 MECHANICAL INSPECTION

MODULE 30-3 Valve Inspection



CE 024 279

GENERAL PHYSICS CORPORATION
Columbia , Maryland

COURSE MODULES

COURSE 30 MECHANICAL INSPECTION

Module 30-1 Pump Inspection
Module 30-2 Pump Functional Testing
Module 30-3 Valve Inspection
Module 30-4 Piping Inspection
Module 30-5 Surface Cleaning Inspection
Module 30-6 Protective Coating Inspection
Module 30-7 Pressure Vessel Inspection
Module 30-8 Rotating Equipment Inspection

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This module was prepared for General Physics Corporation by Ed Wasil and John Espy, General Physics Corporation.

GENERAL PHYSICS CORPORATION

1979

INTRODUCTION

A 1000 megawatt electrical nuclear power plant typically requires over 50 systems for its operation with an average of more than 20 valves per system. Each of these must be carefully inspected and installed.

This module considers all of the major types of valves employed in such a plant. It will examine the characteristics and purposes of each valve and its operation. Also considered in this module are the purposes of the preinstallation and installation inspections as well as the valve testing required for a given valve.

This module should serve as an overview for virtually all the types of valves which would be encountered in a nuclear station. The information presented here is intended for those persons with little or no experience with valves. However, the depth of coverage of this module should also serve to be informative to those with valve inspection experience as well.

MODULE PREREQUISITES

The two previous modules of this course should have been completed.

OBJECTIVES

Upon completion of this module, the student/trainee can:

1. Name the typical pressure boundary parts of valves.
2. Describe characteristics of given types of valves with respect to functions, operations, and relative pressure loss for gate, globe, check, plug, butterfly, and relief valves.
3. State the purpose and briefly describe the operation of thermostatic and mechanical steam traps.
4. Describe seat leakage characteristics of gate and globe valves.
5. Recognize types of valve actuators and briefly describe the operation of given types of actuators.
6. Name four items of information given by a valve nameplate.
7. State the general purpose of given valve inspections which are typically performed as preinstallation and installation inspections.
8. Describe the role of an installation job package.
9. State the purpose of given valve tests including operability, hydrostatic, check valve functional, seat leakage, stroke time, relief set point, and systems control tests.
10. Briefly describe the performance of hydrostatic, seat leakage, stroke time, relief set point, open-close system control and variable positioning system control tests. Include setup, conduct, and examinations performed.
11. Name six sections of a test procedure and generally describe the content of each.

VALVE TYPES

Basic Parts

Basic parts of a valve have common nomenclature regardless of the type of valve. These basic parts are body, bonnet, disk, seal rings, stem, and actuator which are illustrated in Figure 30-3-1.

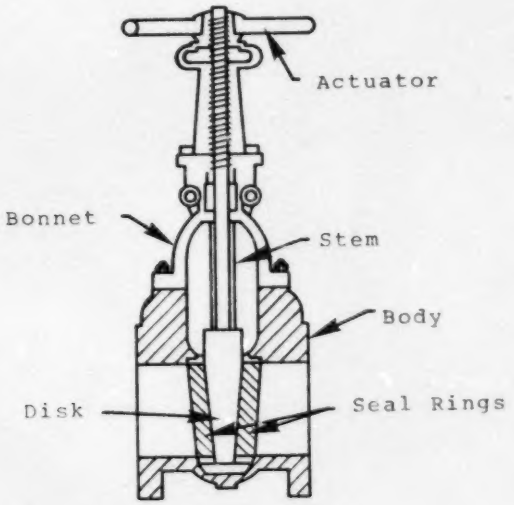


Figure 30-3-1. Basic Parts of Valves

The body is the primary pressure boundary part and serves as the principle element of valve assembly. It provides the seat against which the disk seals off flow. It receives the bonnet through either threaded, bolted, or welded coupling. It receives the inlet and outlet piping through threaded, bolted or welded joints. Valve bodies are either cast or forged and machined at the interfaces with seal rings, bonnet, and inlet and outlet piping.

The bonnet is the next principal pressure boundary part. The bonnet provides a "closure head" for the body

and supports the stem, disk and actuator. Bonnets are cast or forged and connected to the body by threaded, bolted, or welded joints. In all cases, the attachment of the bonnet to the body is considered pressure boundary. This means that the bolts or the weld joint which connects bonnet to body are pressure boundary parts. In most valve types, the bonnet also houses the packing or seal around the stem which prevents stem leakage.

The disk is the next principal pressure boundary part. The disk provides the capability to close the flow path. With the disk closed (seated), full system pressure is applied across the disk if the outlet side is depressurized. For this reason, the disk is a pressure boundary part. Disks are typically forged and, in some designs, hardsurfaced to provide good wear characteristics. A fine surface finish of the seating area of the disk is necessary for good sealing when the valve is closed.

Seal rings provide the seating surface for the disk. In some designs, the body is machined to serve as the seating surface and seal rings are not used. In other designs, forged seal rings are threaded or welded to the body to provide the seating surface. In either case, the surface is often hard-faced by welding deposit to improve wear characteristics. A fine surface finish of the seating area is necessary for good sealing when the valve is closed. Seal rings are not considered pressure boundary parts because the body has sufficient wall thickness to withstand design pressure without relying upon the thickness of the seal rings.

The stem translates the motion of the actuator into disk motion. Stems are typically forged and connected to the disk by threaded or welded joints. For valve designs requiring stem packing or sealing to prevent leakage, a fine surface finish of the stem in the area of the seal is necessary. Stems are typically not considered a pressure boundary part.

The actuator operates the stem and disk assembly. Actuators may be manual handwheels, manual levers, motor operators, pneumatic operators, solenoid operators, or hydraulic rams. In some designs, the actuator is supported by the bonnet. In other designs, a yoke mounted to the bonnet supports the actuator. Except for certain hydraulically operated valves, actuators are outside the pressure boundary. Yokes, when used, are always outside the pressure boundary.

Types of Valves

Six basic types of valves are used in a nuclear power plant. These types are (1) gate valves, (2) globe valves, (3) check valves, (4) plug or ball valves, (5) butterfly valves, and (6) relief and safety valves. Each of these types of valves has unique characteristics which determine its application in power plant systems. These unique characteristics exist for a given type of valve regardless of the system which uses the valve.

Gate Valves

Gate valves are used to start or stop fluid flow, but not to regulate or throttle flow. The name "gate" is derived from the appearance of the disk in the flow stream, which is similar to a gate. The highly simplified drawing of Figure 30-3-2 illustrates a gate valve and its schematic symbol.

As indicated in Figure 30-3-2, the disk is completely removed from the flow stream when a gate valve is fully open. This characteristic offers virtually no resistance to flow when the valve is open and, hence, there is little pressure drop across an open gate valve. When the valve is fully closed, a disk to seal ring contact surface exists for 360° and good sealing is provided. With proper mating

of disk to seal ring, very little or no leakage occurs across the disk when the gate valve is closed. On opening of the gate valve, the flow path is enlarged in a highly non-linear manner with respect to percent of opening. Also the partially open gate disk tends to vibrate from the fluid flow. For these reasons, gate valves are not used to regulate or throttle flow.

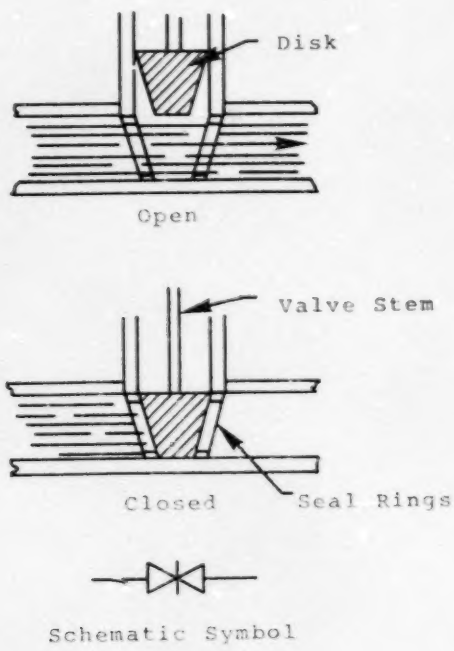


Figure 30-3-2
Simplified Gate Valve and Schematic Symbol

Gate valves are used for start-stop functions. Gate valves may be designed for use at any system pressure. In a system with flow during normal operations, gate valves provide the capability of closing the flow path whenever desired. In a system with no flow during normal operation, gate valves provide the capability to open the flow path

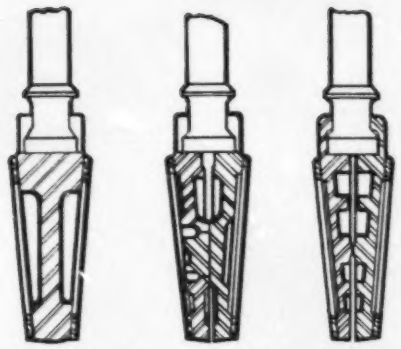
when desired. Hence gate valves are either fully closed or fully open dependent upon their specific application.

The disk of gate valves typically provides seating on both the inlet and outlet sides. Disks may be of parallel or wedge design. Parallel disks have seating surfaces which are perpendicular to the flow path. Wedge disks have seating surfaces which form converging angles to the flow path. Wedge disks may be solid, split or flexible as illustrated in Figure 30-3-3. In most cases, wedge disks seal both the inlet and outlet ports when closed. In such cases, the split and flexible wedges provide some automatic adjustment of seating surfaces with wear. In such designs, seat leakage if any tends to increase as differential pressure across the seat increases. Some flexible wedges and most parallel gate disks provide for sealing only one port. In these designs, the high pressure side pushes the disk open on the high pressure side but forces the disk closed on the low pressure side. With such designs, the amount of seat leakage tends to decrease as differential pressure across the seat increases.

Gate valves employ rising stems or non-rising stems. In rising stem gate valves, the stem rises due to actuator motion and lifts the disk. In non-rising stem gate valves, the stem is threaded into a sleeve which is connected to the disk within the bonnet. Radial motion of the stem is translated into vertical motion of the threaded sleeve such that the sleeve and disk rise within the bonnet but the stem does not rise. Rising stem gate valves are used in pressure applications ranging from low to high. Non-rising stem gate valves are used in high pressure applications.

Gate valves are adaptable to any type of actuator. Differential pressure across the disk causes additional friction between the disk and seal rings. The actuator must be capable of overcoming this friction at design differential

pressure.



(a)= solid
(b)= split
(c)= flexible

Figure 30-3-3. Types of Wedge Disks

Globe Valves

Globe valves are used to stop, start and regulate fluid flow. The name "globe" is derived from the shape of the disc which is similar to a globe. A simplified globe valve is shown in Figure 30-3-4.

As indicated in Figure 30-3-4, the globe valve disk can be totally removed from the flow path or it can completely close the flow path. With proper mating between the disk and seal ring, very little or no leakage occurs across the disk with the valve closed. In addition, the annular space between disk and seal ring gradually closes as the valve is closed. This characteristic gives the globe valve good throttling ability which permits its use in regulating flow. Therefore, the globe valve is used not only for start-stop functions but also for flow regulating functions.

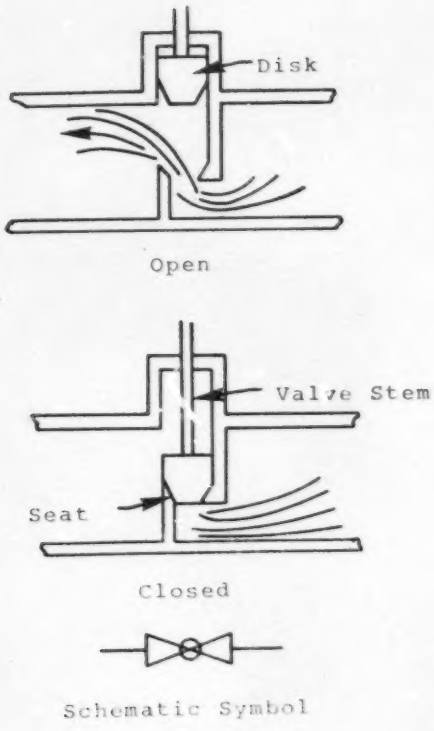


Figure 30-3-4
Simplified Globe Valve and Schematic Symbol

It is generally easier to obtain very low seat leakage with a globe valve as compared to a gate valve. This is because the disk to seal ring contact is more at right angles which permits the force of closing to tightly seat the disk.

Globe valves can be arranged such that the disk closes against the direction of fluid flow or such that the disk closes in the same direction of fluid flow. When the disk closes against the direction of flow, the kinetic energy of the fluid impedes closing but aids opening of the valve. When the disk closes in the same direction as flow, the kinetic energy of the fluid aids closing but impedes opening of the valve. The characteristics make the globe valve preferrable to the gate valve when quick acting stop

valves are necessary.

In any globe valve, the fluid follows a somewhat tortuous path through the valve. This characteristic causes restriction to flow and results in a larger pressure loss across the globe valve as compared to the gate valve. Even with the larger pressure loss, the globe valve is preferrable to the gate valve whenever throttling characteristics or quick-acting characteristics are important.

Other features of the globe valves are similar to those for gate valves. Rising or non-rising stems may be used. Any type of actuator may be used. Globe valves may be designed for any system pressure. However, direction of flow and not valve differential pressure determines whether system conditions are aiding or impeding the actuator.

Check Valves

Check valves permit flow in only one direction. The name is derived from the valve's ability to "check" flow in the undesired direction. A simplified check valve and its schematic symbols are illustrated in Figure 30-3-5.

As indicated in Figure 30-3-5, fluid flow from left to right swings the disk out of the flow path and flow is permitted in that direction. If flow is attempted right to left, the flow pushes the disk against the valve seat and flow is prohibited in that direction.

There are three basic types of check valves (1) swing check, (2) lift check, and (3) stop lift check. Any of these may be designed for use at any system pressure.

The swing check valve, which is illustrated in Figure 30-3-6, uses a hinged disk which "swings" in operation. Flow from inlet to outlet swings the disk open. Flow from outlet to inlet swings the disk closed. Swing check valves offer little resistance to flow when open. This type is used in systems where pressure loss in the open

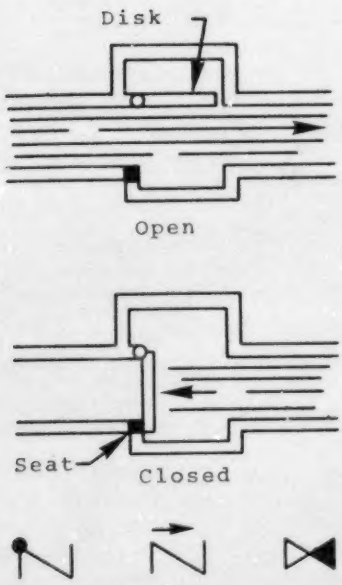


Figure 30-3-5
Simplified Check Valve and Schematic Symbols

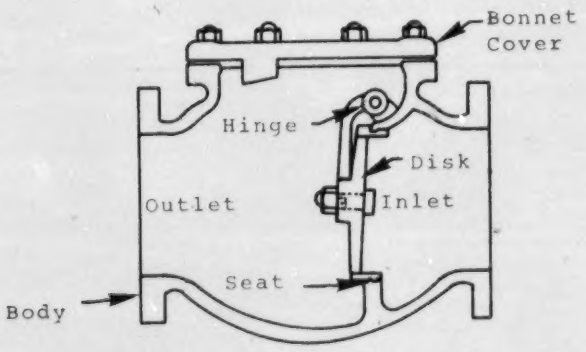


Figure 30-3-6. Swing Check Valve

direction must be minimized

Lift check valves resemble the globe valve. The disk is attached to slide rails on a fixed stem such that the

disk is free to open or close with no stem motion. As illustrated in Figure 30-3-7, the disk of the lift check valve "lifts" off the seat when flow is from inlet to outlet. When flow is reversed, the disk seats and prevents reverse flow. Lift check valves cause a relatively large pressure loss in the direction of flow but typically have less reverse flow leakage than the swing check.

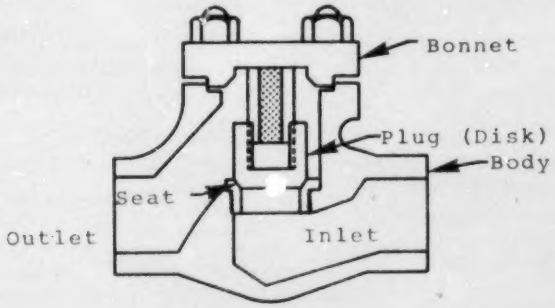


Figure 30-3-7. Lift Check Valve

Stop lift check valves are capable of being forcibly closed by an actuator. As illustrated in Figure 30-3-8, the movable valve stem enters a drilled hole in the disk. When the stem is withdrawn, the disk is free to lift or close dependent on direction of flow. In this condition, the valve is operating as a lift check valve. When the stem is inserted, it forces the disk against the seat. In this condition, the valve serves as a stop valve and prohibits flow in either direction. Stop lift checks are used where the combined functions of check and stop valves are desirable.

Plug Valves and Ball Valves

Plug valves and ball valves are used to stop or start fluid flow. The names are derived from the shape of the disk which resembles a plug or a ball. A plug valve is

illustrated in Figure 30-3-9.

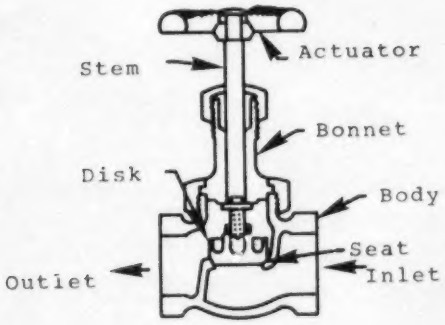


Figure 30-3-8. Stop Lift Check Valve

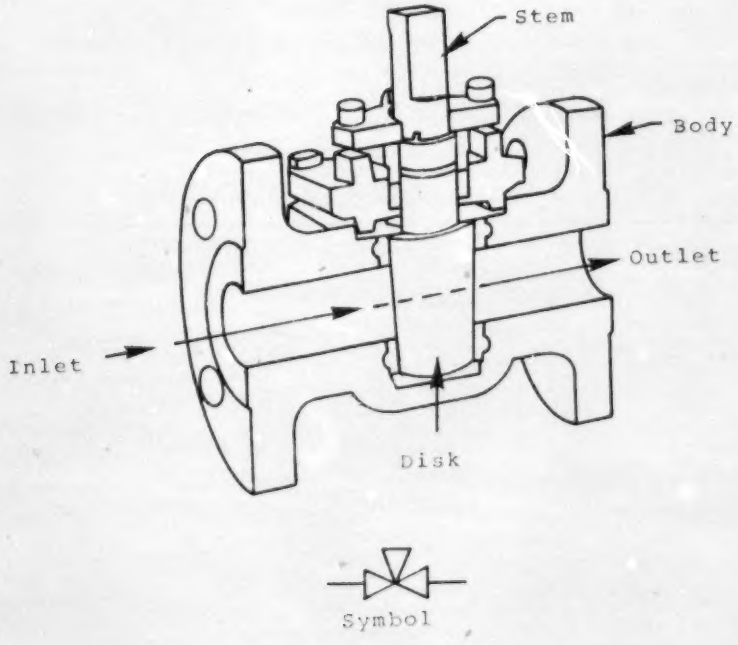


Figure 30-3-9. Plug Valve and Schematic Symbol

The body of a plug valve is machined to receive the tapered or cylindrical plug. The disk is a solid plug with a bored passage at a right angle to the longitudinal axis of the plug. In the open position, the passage in the plug lines up with the inlet and outlet ports of the valve body. When the plug is turned 90° from the open position, the solid part of the plug blocks the ports and stops fluid flow. Ball valves function similarly. The primary difference is that a solid ball with a bored passage is used as the disk.

Plug valves and ball valves offer little resistance to flow in the open position and provide for good sealing in the closed position. Differential pressure across the disk has little effect on power needed to open the valve. These valves are relatively "quick opening". Plug and ball valves can be designed for use at any system pressure. The primary disadvantages of plug and ball valves are (1) cost, (2) relatively rapid wear and corrosion of plug-to-body or ball-to-body seals, and (3) inability to regulate flow.

Plug or ball valves are infrequently used in nuclear power plants. In low pressure systems where plug or ball valves might be used, butterfly valves are typically used because butterfly valves are less expensive and offer essentially the same characteristics.

Butterfly Valves

Butterfly valves are used to stop, start, and regulate fluid flow. The name derives from the action of the disk in the flow stream which is somewhat similar to the wings of a butterfly. A butterfly valve is illustrated in Figure 30-3-10.

Butterfly valves typically use a soft, resilient seat made of rubber or neoprene. The disk is rotated about an axis through its centerline and at a right angle to fluid

flow. In the fully open position, little resistance to flow exists and pressure loss is minimal. In the fully closes position little seat leakage occurs provided the resilient seat is in good condition. At intermediate positions of the disk, throttling of fluid flow occurs although the flow regulating characteristics are not as good as that of globe valves.

Butterfly valves are used in low pressure systems. They are inexpensive and fairly easy to maintain. For these reasons, they are typically used in circulating water systems of nuclear power plants.

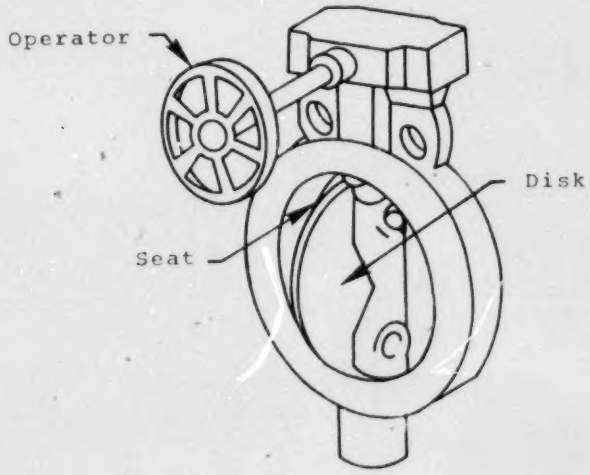


Figure 30-3-10. Butterfly Valve

Relief and Safety Valves

Relief and safety valves prevent equipment damage by relieving accidental over-pressurization of fluid systems. The main difference between a relief valve and a safety valve is the extent of opening at the set point pressure. Relief valves gradually open as the inlet pressure increases above the set point. A relief valve opens only as necessary

to relieve the over-pressure condition. Safety valves rapidly pop fully open as soon as the pressure setting is reached. A safety valve will stay fully open until the pressure drops below a reset pressure. The reset pressure is lower than the actuating pressure setpoint. The difference between the actuating pressure setpoint and the pressure at which the safety valve resets is called blowdown. Blowdown is expressed as a percent of the actuating pressure setpoint.

Relief valves are used for incompressible fluids such as water or oil. Safety valves are used for compressible fluids such as steam or other gases. Safety valves can be distinguished by the presence of an external lever at the top of the valve body which is used as an operational check.

A typical relief valve and the schematic symbol for relief valves are illustrated in Figure 30-3-11. As indicated in the figure, system pressure provides a force which is attempting to push the disk off its seat. Spring pressure on the stem is forcing the disk onto the seat. At some pressure determined by spring conpression, system pressure overcomes spring pressure and the relief valve opens. As system pressure is relieved, the valve closes when spring pressure again overcomes system pressure. Most relief and safety valves open against the force of a compression spring. The pressure set point is adjusted by turning the adjusting nuts on top of the yoke to increase or decrease the spring compression.

Pilot-operated relief valves are designed to maintain pressure through a small passage to the top of a piston connected to the stem such that system pressure closes the main relief valve. When the small pilot valve opens, system pressure is relieved from the piston and system pressure under the disk opens the main relief valve. Such pilot

valves are typically solenoid operated where the energizing signal originates from pressure measuring systems.

Steam Traps

Steam traps are special types of valves which prevent equipment damage by removing accumulated condensate from steam lines. Steam traps are located at low points of elevation and drain condensate from steam lines without allowing steam to escape. Traps operate on a thermal or machanical principle.

Thermostatic traps are usually found in heating systems. This type of trap operates by thermal expansion of an alloy bimetallic strip or a metal bellows partially filled with a volatile liquid. As illustrated in Figure 30-3-12, the bellows type of thermostatic steam trap operates by expansion and contraction of the volatile fluid within the bellows. Steam causes the fluid to boil, increase pressure within the bellows and close the valve by bellows expansion. If condensate enters the trap, some of the volatile fluid condenses causing the bellows to contract and open the valve.

Mechanical steam traps are used in steam power systems. The most common type of mechanical trap consists of a ball float which rises and falls with the condensate level as illustrated in Figure 30-3-13. As condensate level increases, the ball float rises and opens the valve. As condensate level decreases, the ball float falls and closes the valve. The extent of valve opening is determined by the rise of the float.

Another type of mechanical steam trap is the bucket type. As illustrated in Figure 30-3-14, a bucket connected to the valve floats on the condensate. As long as the bucket floats, the valve is closed. When the trap body is nearly filled with condensate, the bucket, which is physically restrained from floating higher, begins filling with

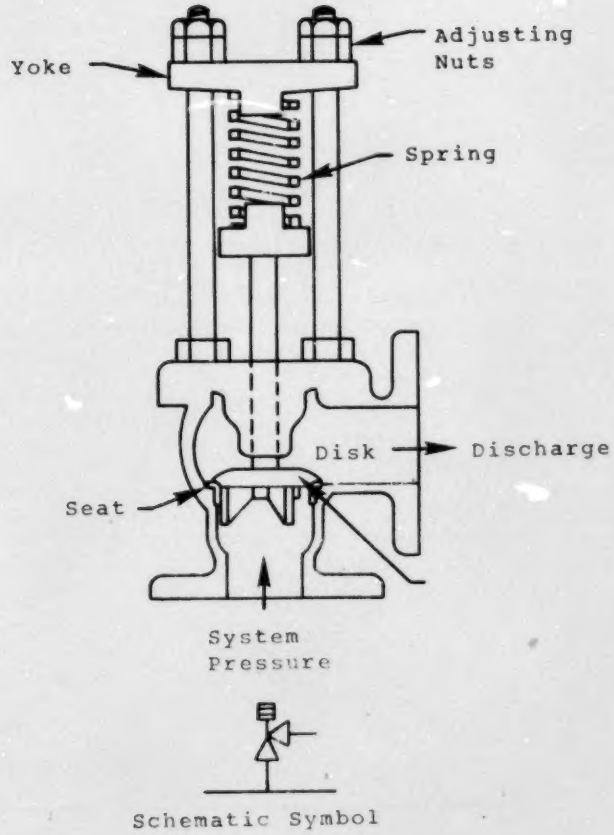


Figure 30-3-11. Relief Valve and Schematic Symbol

condensate. When the bucket is essentially full, it sinks and opens the valve fully. The valve remains open until enough condensate has been discharged to permit the bucket to again float.

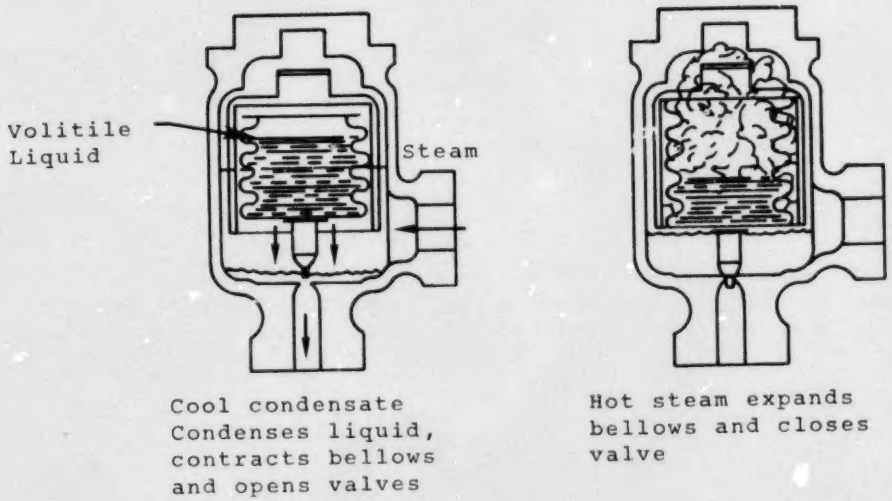


Figure 30-3-12
Bellows Type Thermostatic Steam Trap

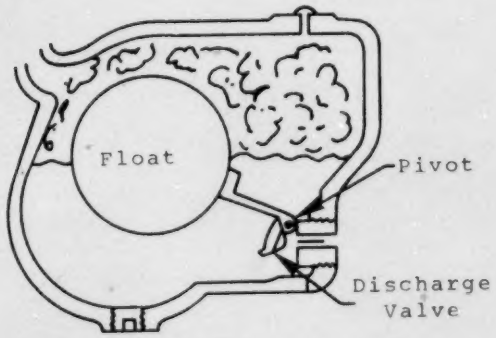


Figure 30-3-13. Ball Float Steam Trap

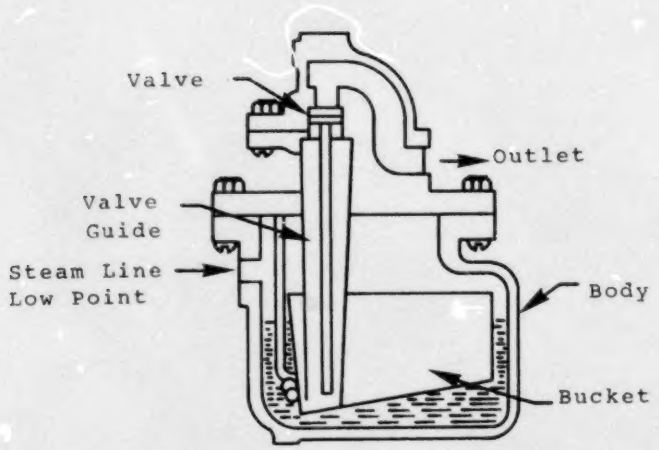


Figure 30-3-14. Bucket Type Steam Trap

VALVE ACTUATORS

Types of Actuators

Engineering selects the type of actuator based on a number of factors including torque necessary to operate the valve and need for automatic actuation. Types of actuators include (1) manual handwheel, (2) manual lever, (3) electrical motor, (4) pneumatic, (5) solenoid, (6) hydraulic piston, and (7) self actuated. All except manual handwheel and lever are adaptable to automatic actuation.

Manual, Fixed or Hammer Actuators

Manual actuators are capable of placing the valve in any position but do not permit automatic operation. The most common mechanical actuator is the handwheel. This type includes (1) handwheels fixed to the stem, (2) hammer handwheels and (3) handwheels connected to the stem through gears.

Handwheels fixed to the stem provide only the mechanical advantage of the wheel. When these valves are exposed to high operating temperatures, valve binding makes operation difficult. A pounding arrangement is used in such cases to facilitate valve operation. The "hammer" handwheel moves freely through a portion of its turn and then hits against a lug on a secondary wheel. The secondary wheel is attached to the valve stem. With this arrangement, the valve can be pounded shut for tight closure or pounded open if it is stuck shut.

If additional mechanical advantage is necessary for a manually operated valve, the valve bonnet is fitted with manually operated gear heads. A special wrench or handwheel attached to the pinion shaft permits one individual to operate the valve where two individuals might be needed without the gear advantage. Because several turns of the pinion are necessary to produce one turn of the valve stem, the operating time of large valves is exceptionally long. The use of portable air motors connected to the pinion shaft decreases the valve operating time.

Electric Motor Actuators

Electric motors permit manual, semi-automatic, and automatic operation of the valve. Motors are mostly used for open-close functions although they are adaptable to positioning the valve to any point opening. The motor is usually a small, reversable, high speed type connected through a gear train to reduce the motor speed and thereby increase the torque at the stem. Direction of motor rotation determines direction of disk motion. The electrical actuation can be semi-automatic as from a push button which starts the motor or automatic, as when the motor is started by a control system. A handwheel which can be engaged to the gear train provides for manual operation of the valve. Limit switches

are normally provided to stop the motor automatically at full valve opening and closure. Limit switches are operated either physically by position of the valve or torsionally by torque of the motor.

Hydraulic Actuators

Hydraulic actuators provide for semi-automatic or automatic positioning of the valve. These actuators use a piston to convert a signal pressure into valve stem motion. Hydraulic fluid is fed to either side of the piston while the other side is drained or bled. Water or oil is used as the hydraulic fluid. Solenoid valves are typically used for automatic control of the hydraulic fluid to direct either opening or closing of the valve. Manual valves can also be used for controlling the hydraulic fluid and thus provide semi-automatic operation.

Pneumatic Actuators

Pneumatic actuators provide for automatic or semi-automatic valve operation. These actuators translate an air signal into valve stem motion by air pressure acting on a diaphragm or piston connected to the stem. Pneumatic actuators are used in throttle valves for open-close positioning where fast action is required. When air pressure closes the valve and spring action opens the valve, the actuator is termed direct-acting. When air pressure opens the valve and spring action closes the valve, the actuator is termed reverse-acting. Duplex actuators have air supplied to both sides of the diaphragm. The differential pressure across the diaphragm positions the valve stem. Automatic operation is provided when the air signals are automatically controlled by circuitry. Semi-automatic operation is provided by manual switches in the circuitry to the air control valves.

Self-Actuated Valves

Self-actuated valves use system fluid to position the valve. Relief valves, safety valves, check valves, and steam traps are examples of self-actuated valves. All of these use some characteristic of the system fluid to actuate the valve. No source of power outside the system fluid energy is necessary for operation of these valves.

Solenoid Actuated Valves

Solenoid actuated valves provide for automatic open-close valve positioning. Most solenoid actuated valves also have a manual override which permits manual positioning of the valve for as long as override is manually positioned. Solenoids position the valve by attracting a magnetic slug attached to the valve stem. In single solenoid valves, spring pressure acts against the motion of the slug when power is applied to the solenoid. These valves can be arranged such that power to the solenoid either opens or closes the valve. When power to the solenoid is removed, the spring returns the valve to the opposite position. Two solenoids can be used to provide for both opening and closing by applying power to the appropriate solenoid.

Single solenoid valves are termed fail open or fail closed dependent on the position of the valve with the solenoid deenergized. Fail open solenoid valves are opened by spring pressure and closed by energizing the solenoid. Fail closed solenoid valves are closed by spring pressure and opened by energizing the solenoid. Double solenoid valves typically fail "as is". That is, the valve position does not change when both solenoids are deenergized.

Speed of Power Actuators

Plant safety considerations dictate valve speeds for certain safety related valves. Where a system must be

very quickly isolated or opened, very fast valve actuation is required. Where the opening of a valve results in injection of relatively cold water to a hot system, slower opening is necessary to minimize thermal shock. Engineering design selects the actuator for safety related valves based on speed and power requirements and availability of energy to the actuator.

In general, fastest actuation is provided by hydraulic, pneumatic, and solenoid actuators. However, solenoids are not practical for large valves because their size and power requirements would be excessive. Also, hydraulic and pneumatic actuators require a system for providing hydraulic or pneumatic energy. The speed of actuation in either case can be set by orificing the hydraulic or pneumatic lines.

Electrical motors provide relatively fast actuation. Actual valve speed is set by the combination of motor speed and gear ratio. This combination can be selected to provide full valve travel within a range from about two seconds to many seconds.

Valve Position Indication

The reactor operator requires indication of the position of certain valves to permit knowledgeable operation of the plant. For such valves, remote valve position indication is provided in the form of position lights which indicates if valves are open or closed. Remote valve position indication circuits use a position detector which senses stem and disk position or actuator position. One type of position detector is the mechanical limit switch, which is physically operated by valve movement. Another type is magnetic switches or transformers which sense movement of their magnetic cores which are physically operated by valve movement.

Local valve position indication refers to some visually discernable characteristic of the valve which indicates valve

position. Rising stem valve position is indicated by the stem position. Nonrising stem valves sometimes have small mechanical pointers which are operated by the valve actuator simultaneously with valve operation. Power actuated valves typically have a mechanical pointer which provides local valve position indication. On the other hand, some valves do not have any feature for position indication.

PREINSTALLATION INSPECTION

Purpose and Scope

Preinstalltion inspections of valves verify that the valve and the installation area comply with specified requirements. Preinstallation inspections are required for valves intended for safety related systems. When a valve is received at the nuclear power plant site, it is receipt inspected for conformance with the valve design specification. Accepted valves are tagged with an acceptance tag and placed into storage until it is needed for installation. Preinstallation inspection confirms that the identity and condition of the valve is maintained. Installation areas are inspected to verify that procedures, trained personnel, and installation equipment are available as required by the system design specification and installation drawings. These installation inspections are applied to (1) identification, (2) processes and procedures, (3) valve physical conditions, and (4) site conditions.

Identification Inspections

The installation contractor must establish a quality assurance program which ensures items are properly installed into their correct location as specified by installation drawings. The quality assurance program provides for maintaining lists or procedures which designate the exact components to be installed in a given system. At release of a valve from storage to the installation area, the inspection activity confirms that the designated valve is in fact released.

Valve identification is provided by the name plate and the accept tag. The data on the name plate is verified as correct by receiving inspection and thereafter the name

plate is used as acceptable indication of valve identity. The valve design specification stipulates what is required on the name plate. It typically requires (1) valve manufacturer's name, (2) type of valve, (3) design pressure and temperature, (4) code classification, (5) valve serial number, and, (6) national board number.

Preinstallation inspectors compare name plate data and the accept tag data with the installation procedures to confirm that the correct valve is released for installation. Also, a roving inspector is typically assigned to periodically check released valves to confirm that their identity is maintained.

Inspection of Processes and Procedures

Installation procedures and drawings are prepared for use by the installation contractor. For a given installation activity, the procedures and drawings applicable to that activity are collectively termed "job package". The job package may be attached to the component at release from storage or it may be issued to the supervisor of the installation group. The job package delineates all necessary instructions for installing an item such as a valve.

Preinstallation inspectors confirm that a complete job package is on hand and that its provisions are met. This inspection may be on a roving basis such that an inspector proceeds from one installation activity to another as checks are completed. Checks are typically made to verify (1) availability of approved procedures and drawings, (2) qualification of personnel as required, (3) compliance with prerequisites, (4) availability of necessary handling and fixturing devices, and (5) compliance with safety requirements.

- Approved procedures and drawings - In addition to confirming that the correct job package is available,

the inspector checks for other procedures which are required by the installation procedure or drawing. Such other procedures typically involve special processes which will be required for the installation work. Examples include welding procedures, cleaning procedures, heat treating procedures and nondestructive examination procedures.

- Qualification of personnel - The inspector confirms that persons assigned to the installation are qualified if formal qualifications are required. Welders and nondestructive examination personnel are required to be qualified. Dimensional and visual inspectors may also be required to be qualified.
- Compliance with prerequisites - The installation procedure specifies any prerequisites which must be met prior to installing a valve. Examples include removal of packing and plugs which protected the valve internals, and cleaning the general area.
- Handling and fixturing - Dependent on the type and size of valve, various handling equipment and fixtures are necessary for safe movement and positioning of the valve. The inspector verifies availability of such equipment as specified by the job package.
- Safety - The inspector verifies compliance with safety precautions stipulated by the job package. For valve installation, the safety requirements are typically those associated with routine installation activities such as use of hard hats and eye protection.

Inspection of Valve Physical Conditions

During the inspection of installation processes and procedures, the inspector also checks the physical condition of the valve. These checks insure that (1) the quality of the valve has been maintained, (2) any prior reported noncon-

formances have been corrected, and (3) the valve is adequately clean for installation.

Checks on maintenance of valve quality look for physical damage from mishandling and for unique conditions applicable to the valve. Examples of unique conditions are:

- Weld end preparations are undamaged for valves which will join inlet or outlet piping by welding.
- Threads are undamaged for valves which will join inlet and outlet piping by threaded union.
- Excessive rusting has not occurred.
- Protective caps and plugs are kept in place until installation begins.

Inspection of Site Conditions

During the inspection of installation processes and procedures, the inspector also checks site conditions for compliance with the requirements of the job package. These checks verify that site conditions have been established as required to avoid adversely affecting the quality of the valve. Examples include:

- Protection from adjacent installation activities such that there is little risk of damage to the valve.
- Protection from inclement weather such as snow, rain, sleet, etc.
- Installation of permanent or approved temporary supports on which the valve will be mounted.

INSTALLATION INSPECTIONS

Purpose and Scope

While preinstallation inspections verify readiness to proceed with installation, installation inspections verify that required quality is obtained by the installation work. To accomplish this purpose, critical steps in the instal-

lation process are selected for inspection and other installation steps are inspected on a roving basis. These inspections encompass (1) control of procedures and processes, (2) nondestructive examinations, (3) work in progress, and (4) final installation.

Control of Procedures and Processes

Inspections on the control of procedures and processes verify that established controls are being implemented throughout the installation time cycle. These inspections are typically performed on a roving basis and check for procedural compliance by the various steps of installation work. These inspections typically check for (1) control of revisions to procedures and drawings, (2) use of approved procedures and materials by qualified personnel, (3) indication of quality status, (4) compliance with sequence, (5) control of nonconformances, (6) recording as-builts, and (7) completeness of inspections and tests:

- Control of revisions to procedures and drawings - The procedures and drawings contained or referenced by the job package may require revision for a number of reasons. Whenever a job package has been released to the installation contractor, any subsequent revision to applicable procedures or drawings must result in providing to the installation contractor the revised document. Installation inspections confirm that the latest approved revision levels of procedures and drawings are in use by the installation contractor.
- Use of qualified personnel, procedures, and materials - Installation inspections confirm that personnel actually performing the work are qualified as required, that procedures in use are qualified or approved, and that materials being used are those specified by the procedures and drawings. Examples of

materials include threaded fasteners, welding materials, and stem packing.

- Indication of quality status - As installation proceeds, the status of installation including inspections and tests must be clearly identifiable. Such indication of status may be provided by inspection reports, tagging the valve or signoff of installation check lists. The installation inspector confirms that indication of quality status is maintained.
- Compliance with sequence - The job package includes the sequence of steps for proper installation, inspection and test of valves. The installation inspector verifies compliance with the specified sequence.
- Control of nonconformances - Inspections and tests required by the job package may identify nonconforming conditions. In such cases, the valve is tagged as nonconforming and a nonconformance report is initiated. Engineering determines what correction of the nonconformance is necessary and issues appropriate instructions. Until completion of the correction, the valve status must be maintained as nonconforming. The installation inspector verifies the tagging of nonconforming valves and maintenance of such tagging until the nonconformance is corrected.
- Recording of as-builts - The job package may require that certain dimensions be accorded to reflect the as-built values of the installed valve. For example, the actual, installed location of the valve inlet and outlet nozzles with respect to a datum may be needed to permit fabrication of a piping assembly which will eventually connect to the valve. For pressure boundary valves subject to the ASME Boiler and Pressure Vessel Code, an installation

data form is completed which lists each installed valve. The installation inspector verifies that required as-built information is recorded as installation progresses and that the installation data form is completed.

- Completeness of inspection and test - The job package stipulates the inspections and tests to be performed during the installation process. The installation inspector verifies that inspection and test reports are prepared for each required inspection and test.

Nondestructive Examinations

Nondestructive examinations of valve installations are typically required only for welded joints such as welds between inlet and outlet piping and valve body. Valves with bolted or threaded pipe connections do not require nondestructive examinations during valve installation. When required, nondestructive examinations may consist of liquid penetrant, magnetic particle, radiography or ultrasonic tests. For weld joints in magnetic materials, magnetic particle and radiography are typically required. For weld joints in nonmagnetic materials, liquid penetrant and radiography are typically required. For welds which are subject to later inservice inspection by ultrasonic testing, an ultrasonic test is performed at installation to establish a known "base-line" for comparison with later inservice ultrasonic tests. Whenever nondestructive testing is required, it must be performed to an approved procedure by qualified persons.

Work in Progress

Installation inspections are planned for work in progress to ensure that critical installation requirements are met. For critical requirements, inspection hold points are

established which require installation work to stop at such points until the inspection is performed. For installation work steps considered not critical, a roving inspector periodically checks for compliance with the job package. Typical hold points for valves include:

- Orientation - Inspection verifies that the valve is mounted with inlet, outlet and actuator connections in the correct orientation. Check valve orientation is particularly important.
- Torquing of threaded fasteners - Bolted mounts, pipe-to-body flanges, and pipe hangers are torqued to specified values. The installation inspector typically witnesses torquing of threaded fasteners.

The remainder of installation work is typically checked periodically by a roving installation inspector. Such addition work activities include cleaning, welding, pipe fitting, housekeeping, and protection of valve internals from foreign materials.

Final Installation Inspection

Once the valve is installed, the installation inspector makes a final inspection which serves to report the acceptance of the installation. The final inspection verifies that:

- All steps of the job package have been completed including all inspections and tests and correction of any nonconformances.
- External connections have been completed including piping and power connections as required.
- Limit switches, interlocks, and stops are installed.
- All specified mounts, hangers, and supports are installed.
- All specified temporary protective plugs, covers, and strainers are in place.

At this point, installation inspection has verified that the correct valve has been properly installed in the right location. The valve is now ready for testing. However, the entire system which contains the valve must typically be installed prior to conducting most tests.

VALVE TESTS

Tests by Manufacturer

Design specifications for each type and kind of valve are prepared by or under the direction of the owner of the nuclear power plant. The valve manufacturer produces valves in accordance with these design specifications and performs valve tests as specified by them. Hydrostatic testing of assembled valve is required for most valves. In addition, certain valves may require seat leakage tests and stroke time tests. Also, a sample number of each design of relief and safety valves is subjected to full flow pressure relief testing. Each relief and safety valve is tested for proper set point pressure.

Tests by the valve manufacturer ensure that the valve satisfies design requirements for that valve. After the valve is installed at the power plant site, tests are conducted as appropriate to the function and importance of the valve with respect to safe operation of the plant. The tests performed at the plant site are the same type as those performed by the valve manufacturer except that system design requirements apply.

Tests after Installation

Thousands of valves are used in the various systems which comprize the nuclear power plant. These valves differ by types, pressure ratings, sizes, materials, and type of actuators. The extent of testing of any given valve is

based on the safety related function of the valve as stipulated by engineering. About 500 valves are subjected to more than a simple operability test. The types of testing include (1) valve operability, (2) hydrostatic or pneumatic pressure, (3) seat leakage, (4) stroke time, (5) relief set point, and (6) control system tests. The techniques for performing these tests are essentially the same regardless of valve type.

Valve Operability Tests

Valve operability tests verify that the installed valve operates without binding. This test is an installation tests which is applied to gate, globe, plug, ball, and butterfly valves upon completion of their installation. The test is a relatively simple test and is performed by using the installed actuator and confirming operation of the valve through a complete cycle, i.e. open-close-open or close-open-close.

Automatic controls which may be associated with power valve actuators are not tested by the operability test. Such controls are tested later as system control tests. However, the operability test verifies functioning of limit switches on power actuators as do the system control tests.

Valve operability tests are performed prior to filling the system for hydrostatic or leak testing. Satisfactory completion of the operability tests ensures that the valves are operable and indicates that their use should be reliable during later preoperational testing.

Hydrostatic and Pneumatic Pressure Tests

Most power plant fluid systems are pressure tested as a preoperational test. Pressure tests of the system also tests valves within the system. These tests verify that valve pressure boundary parts do not leak except as may be permitted by the design specification.

Valves within the system are considered in two categories. First, certain stop valves are closed to establish the boundary limits of the system. The extent of testing of these boundary valves depends on whether test pressure is permitted by the valve arrangement to be applied to the bonnet. Second, valves between the boundary isolation valves are open to permit test of the entire system. Test pressure is applied to all pressure boundary parts of these valves except perhaps the disks.

Most system pressure tests are hydrostatic tests. The system boundaries are established and isolated by closing stop valves and blanking openings which may exist at the time. The system is then filled with water and vented at all high points to ensure removal of air. This may require loosening of stem packing glands of large valves until a stream of water leaks from around the valve stem. Stem packing glands are then retorqued to the specified amount. Retorquing may be designated as a witness point by a quality assurance representative. After filling and venting is completed, system pressure is increased by positive displacement pumps discharging into the system. Visual inspections for leaks are performed at designated pressure increments and at full test pressure. Full test pressure is typically 120% of design pressure.

Visual inspection for hydrostatic leaks in valves gives particular attention to valve stem packing, bonnet-to-body joint, body-to-pipe joints for both inlet and outlet piping, and external surface areas of the body and bonnet. Threaded connections, bolted joints and stem packing are the most prevalent locations of leaks. Welded joints, bodies, and bonnets may contain leaks in the form of through-wall cracks. Closed valves which establish system boundary may permit seat leakage. Such seat leakage is detectable by drainage from downstream drain lines if direct visual observation of the seat is not possible.

System which must be pressure tested but which cannot support the weight of water or where the water cannot be

completely removed as required are pneumatically pressure tested. After isolation of system boundaries, air is charged into the system to the designated test pressure. With the system at test pressure, system pressure is monitored and a bubble solution is applied to mechanical and welded joints to examine for leak.

Stop valves which provide pressure isolation functions for systems also require pressure testing of disks. Oftentimes these are the same valves used as boundary isolation valves for the system pressure test. However, if valves which require pressure tests of disks are not boundary isolations for system tests, another pressure test is required using such valves as the new boundary isolations.

Acceptance criteria for leaks with respect to valves typically includes (1) no detectable leak through wall and at body-to-pipe and bonnet-to-body joints and (2) leaks at stems and seats only as permitted by the design specification. The maximum permissible leak rate for stems and seats is dependent on the functions of the specific system and the valves being tested. The design specification stipulates whether detectable leakage is permitted and, if so, the maximum leak rate.

Check Valve Functional Tests

Check valve functional tests verify that check valves permit flow in the desired direction and prohibit flow in the undesired direction. These tests are normally performed in conjunction with either hydrostatic tests or system flow tests.

One common use of check valves is in systems with parallel flow paths but flow in only one path is desired. An example is the parallel connection of centrifugal pumps as illustrated in Figure 30-3-15.

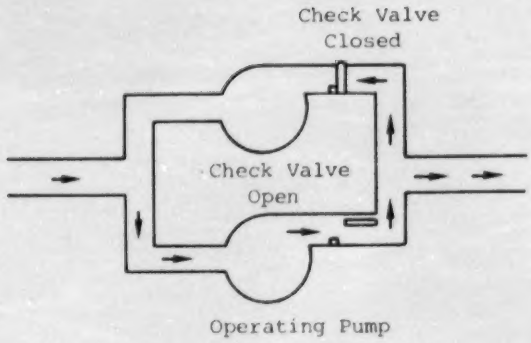


Figure 30-3-15. Check Valves in Parallel Pump System

As illustrated in Figure 30-3-15, discharge from the operating pump attempts to reverse flow through the idle pump. If this were to happen, most of the flow would go through the idle pump with little flow to the system which invariably offers more resistance to flow. Reverse flow through the idle pump is prevented by the check valves. Testing of such check valves is performed by operating each pump in succession and observing pump discharge pressure. If the check valve for the idle pump permits reverse flow, pump discharge pressure would be lower than anticipated. Also, "windmilling" of the idle pump by reverse flow could be detected visually by observing the pump shaft.

Another common use of check valves is to prevent reverse flow in systems should a reverse pressure situation arise. Flow from a pressurized system to a lower pressure system could reverse if pressure were lost in the supply system. Fluid transfer by pump from one system to a higher pressure system could reverse if pumping power were lost. Check valves in the flow lines prevent such reverse flow as illustrated in Figure 30-3-16.

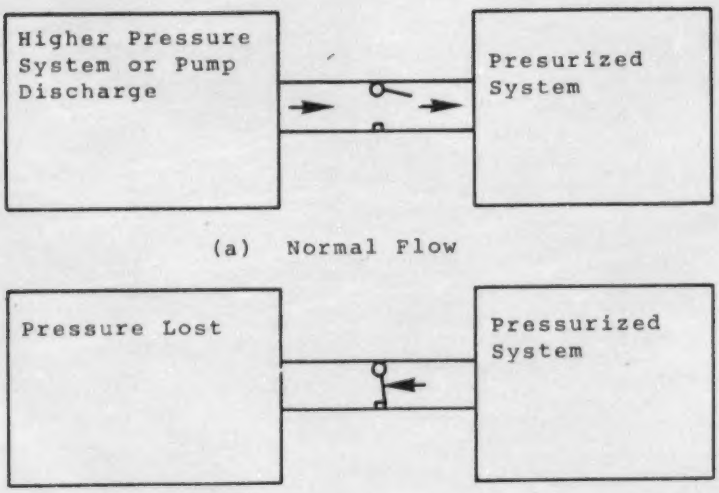


Figure 30-3-16
Check Valve Prevention of Reverse Flow

Testing of check valves used to prevent reverse flow requires application of a differential pressure across the valve in the reverse flow direction. For preoperational testing, this is accomplished by a positive displacement pump connected between the outlet side of the check valve and a stop valve in the line. Pressure in the line is increased to test pressure and pump discharge is secured. Either pressure stability in the line or no leakage from a drain on the inlet side of the check valve indicates proper functioning of the check valve. If required by the system design specification, seat leakage of the check valve in the reverse flow direction is also measured.

Seat Leakage Tests

Relatively few valves require seat leakage tests. Those stop and check valves are tested whose seat leakage

is important with respect to safety related functions. Such valves have specified maximum seat leak rates at designated differential pressures across the disk. The differential pressures are those anticipated when the valve performs its safety related function. The seat leakage test verifies that actual seat leakage at the specified differential pressure is less than maximum specified.

Seat leakage tests are performed by establishing specified differential pressure across the disk in the same direction as that experienced during the safety related function of the valve. Because various modes of plant operation may result in more than one differential pressure of concern, seat leakage tests may be required at more than one differential pressure.

Seat leakage tests may be performed in conjunction with hydrostatic tests if test pressures are identical. If lower pressures are required for the seat leakage tests, the tests are typically performed immediately after hydrostatic testing. A valve may also be tested for seat leakage by pressurizing only a portion of the system. In any of these circumstances, the basic test arrangement is similar to that illustrated in Figure 30-3-17.

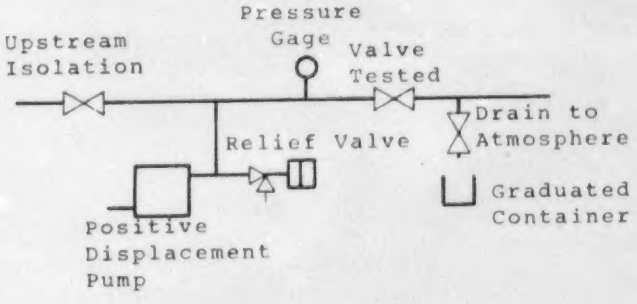


Figure 30-3-17. Seat Leakage Test Basic Configuration

As indicated by Figure 30-3-17, the basic equipment necessary for seat leakage tests are test pump, pressure gage, and graduated collection container. With test pressure applied, seat leakage is collected for a timed interval. The volume of leakage collected divided by the collection time equals the leak rate.

Stroke Time Tests

Stroke time tests verify that time of full valve travel is within specified limits. This test applies to safety related valves whose time of opening or closing is important to safety features of the system. Examples of quick acting valves include those used for containment isolation and containment spray. An example of a deliberately slow acting valve is the pressurizer spray control valve in a pressurized water reactor plant.

Valves which require stroke time tests may be actuated automatically or semi-automatically in normal operations. But for stroke time testing, push buttons, switches, or manual overrides on control valves are used to apply power to the actuator, i.e. semi-automatic actuation is used. In most cases, a stop watch provides sufficient accuracy for measurement of stroke time. If more accurate measurement is needed, chart recorders are used with input signals from valve indication and actuator power circuits. The time is measured from the time of applying power to the actuator until the time of completion of full valve travel. Typical times are from 2 to 8 seconds for quick acting valves.

Relief and Safety Valves Setpoint Tests

Setpoint tests of relief valves and safety valves verify that the valve opens and reacts within specified pressure limits. These tests are not to be confused with

"full flow" relief and safety valve tests. Full flow tests are performed at special testing facilities where an over pressure can be maintained at full rated flow of the valve when it is fully open. Such tests are used to "qualify" a relief or safety valve design and are beyond the testing capabilities at a nuclear power plant site.

Self-actuated relief or safety valves are removed from their system and tested at special test stands. However, initial set point testing at the test stands may occur before installation of the relief into the plant system. Set point tests are not performed with the self-actuated relief installed because there is some risk of damage to the system. Typical test arrangements are illustrated in Figure 30-3-18.

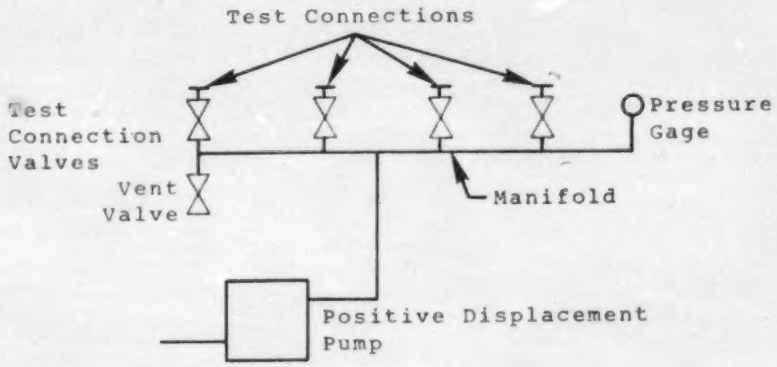


Figure 30-3-18
Basic Arrangement for Set Point Testing

Referring to Figure 30-3-18, a test manifold with multiple test connections permits mounting of self-actuated relief or safety valves to each test connection and valving in the relief to be tested. This arrangement saves time in conducting tests of many reliefs. With reliefs

mounted to the test connections and all test connection valves closed except one, the pump is started. When water discharges from the vent, the vent valve is closed. When the relief with the test connection valve lifts, the pressure is noted at the point of lifting and again at reseating if reseating limits are also specified. Then if specified limits are not met, valve spring tension is adjusted by turning the adjusting nuts in the appropriate direction. The relief valve is then retested by closing the vent. When lift point limits are met and with the vent open to lower pressure, the test connection valve for the next relief is opened and the test connection valve for the relief already tested is closed. The vent is then closed and pressure rises until the lined-up relief lifts. This sequence is followed until each relief is verified to lift within specified limits.

Relief having solenoid actuated pilot valves are tested while installed into the plant system. For these tests, the system need not be fully pressurized. A test signal in the pressure indicating circuitry is used to simulate pressure. The test signal actuates a bistable at its setpoint which in turn actuates the solenoid. The bistable set point is adjusted to coincide with the designated relief set point.

Actual opening of the pilot actuated relief is verified by one of several ways. If system temperature is above ambient, increased temperature downstream of the relief indicates that the relief has opened. A drain to atmosphere downstream of the relief may be used. Also, effect on system pressure or level may be used.

Control System Tests

Control system tests verify that automatic positioning of valves occurs as designed. These tests apply to those relatively few valves which are automatically positioned by

plant parameters such as pressure, temperature, flow, and level. Control systems may provide open-close functions at some setpoint or may provide continuous positioning in proportion to selected plant parameters.

The block diagram of Figure 30-3-19 illustrates a valve control system which serves an open or close function. The plant parameter is sensed by the detector which gives a proportional signal to the level indicating circuitry. The value of the parameter is read on the indicating meter and continuously supplied to the bistable. The bistable operates when the parameter value reaches the setpoint of the bistable. The bistable may be designed for actuation at its setpoint on an increasing parameter value or a decreasing parameter value. When the bistable actuates, it operates a control device which applies power to the valve actuator. The control device is a circuit breaker or motor controller for motor actuated valves and typically a solenoid operated valve for hydraulic and pneumatic actuators. If the valve to be controlled is solenoid operated, the bistable directly operates the solenoid. When the control device is operated by the bistable, power is applied to the valve actuator to either open the valve if it is normally closed or to close the valve if it is normally open. Typically, an indicator light or alarm signals the reactor operator that the control system has ordered valve actuation.

The open-close control system may monitor more than one plant parameter. In such cases, a detector, level circuitry and bistable for each parameter are provided in parallel. The output of each bistable may feed through an "OR" or "AND" circuit. OR circuits permit any one of the bistables, and hence any parameter, to actuate the valve. AND circuits require output from all bistables or any combination of bistables to actuate the valve.

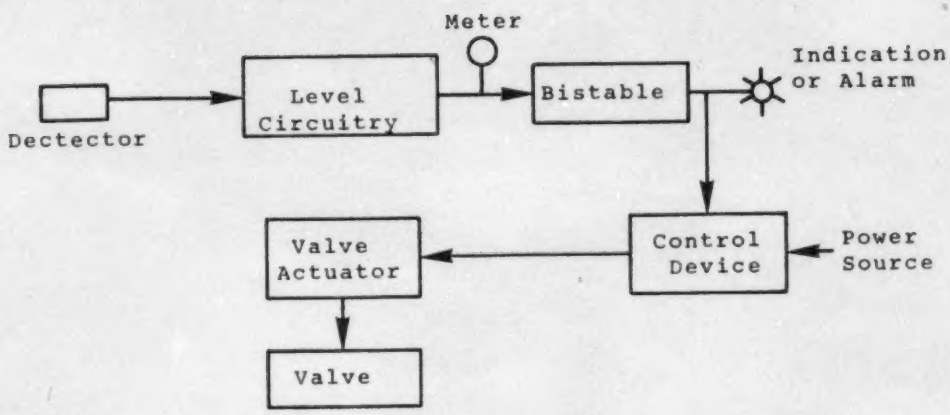


Figure 30-3-19. Open-Close Control System

Tests of open-close control systems are performed by simulating the parameter value from the level circuitry. The operation of the bistable, control device, and valve actuator are observed and the parameter level at which actuation occurs is compared to the specified set point. The bistable is adjusted as necessary to initiate valve actuation at the specified set point.

The block diagram in Figure 30-3-20 illustrates a continuous positioning control system. This type of system is used for adjusting throttle valves to regulate flow. For example, pressurized water reactors use this type system to control steam generator water level by regulating feed flow. Boiling water reactors use this type of system for controlling reactor vessel water level. The controlling plant parameters in these examples are typically steam flow, feed flow, and water level.

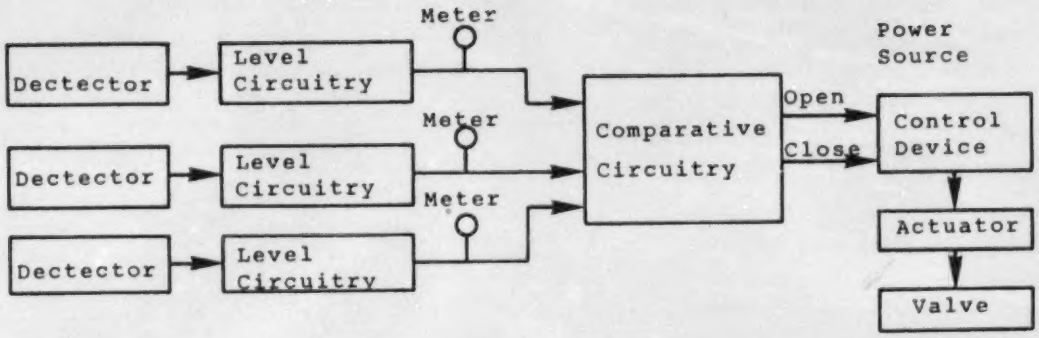


Figure 30-3-20. Variable Position Control System

The circuitry for variable position control systems is similar to that for open-close control systems except that comparative circuitry is substituted for bistables. The comparative circuitry continuously compares the plant parameters and issues a signal when an "out-of-balance" condition exists. The output signal is an open or close signal dependent on which direction of valve movement would restore balance to the parameters. Using the example of steam generator water level control, if steam flow exceeds feed flow a comparator initiates opening of the feed water throttle valve until feed flow equals steam flow. The third parameter typically has an overriding effect. For example, if steam flow exceeds feed flow but water level is too high, a valve opening signal does not occur until level decreases sufficiently to remove the overriding effect.

Variable position control systems are tested by simultaneously simulating plant parameters. At various combinations of parameter values, valve positioning is observed and compared with design requirements. Adjustments are made as necessary to the comparative circuits to provide for proper valve positioning.

TEST PROCEDURES

Purpose

Written test procedures are used to more positively ensure the proper performance of testing. Procedures are prepared for each type of valve test except for installation operability testing. The installation job package contains necessary instructions for ensuring valve operability and with the possible exception of certain power actuated valves, separate procedures are unnecessary for operability testing. As previously noted, most valve testing is performed in conjunction with preoperational testing and cold functional testing of systems containing the valve. These tests are repeated for safety related valves at intervals during the life of the plant to verify continued satisfactory functioning of safety related valves.

Content

Each test procedure provides instruction within at least seven topics. These topics are (1) title, number and revision of the procedure, (2) test objectives, (3) test equipment, (4) prerequisites, (5) limitations, (6) procedure, notes and cautions, and (7) acceptance criteria.

- Title, number, and revision - Each test procedure is uniquely identified by title, number, and revision to permit convenient reference to a given procedure. The title typically reflects the nature of the test, e.g., "stroke time testing of High Pressure Safety Injection Valves." The number is a nonrepetitive assigned number selected arbitrarily or in accordance with a system numbering scheme. The revision is indicated by ascending numerical or alphabetical identifiers.
- Test objectives - The specific functional design

features of the valve which are tested by the procedure are stated. For example, "to measure seat leakage of valves ____, ____, and ____."

- Test equipment - The procedure lists each type of test equipment which will be needed for performing measurements required by the procedure.
- Prerequisites - This section of the test procedure lists each prerequisite condition which must be established in order to perform the test. For example, prerequisite positioning of valves, availability of power sources, installation of temporary blanks on system openings, and availability of other systems necessary for supporting the test.
- Limitations - this section of the test procedure identifies any limitations applicable to the test as an entity. For example, system temperature may be required to be above a stated minimum or the test may not be permissible if fuel is loaded.
- Procedure, notes, and cautions - This section of the test procedure states step-by-step instructions for performing the test, measuring test parameters and recording results. The first steps typically require verification of compliance with prerequisites and limitations. It then proceeds with steps in the correct sequence for performing the test. Notes are added as necessary to provide supplementary information to the tester. For example, "Note: the next step energizes the motor actuator to close the valve." Cautions are added as necessary for safety considerations. For example, "Caution: the next step places total reliance on the check valve for preventing reverse flow. As the stop valve is opened during the next step, observe system pressure. If pressure decreases, promptly close the stop

valve and report conditions to the test supervisor." Notes and cautions, when used, are placed immediately prior to the procedural step to which they apply.

- Acceptance criteria - This section of the test procedure states the specific acceptance criteria for the test. Test results are compared to these criteria to determine if the valves have demonstrated acceptable functioning. Sometimes, measurements made during testing require further engineering calculations in order to permit comparison with acceptance criteria.

EXERCISES

The following exercises serve to reinforce the material presented in this module.

1. Using the sample valves as described in the Procedures section of this module, dismantle each valve and sketch its construction. With each sketch include a brief discussion and where it may be typically used as indicated in the Data Table section of this module.

2. Name the parts of a valve which are typically pressure boundary parts.

3. State if the relative pressure loss across the following valves is high or low with the valve fully open and explain why.
   a. gate valve

   b. globe valve

   c. swing check valve

   d. lift check valve

   e. butterfly valve

4. Explain how fluid flow affects ease of operating a globe valve.

5. Name the type of valve represented by:

a.

b.

c.

d.

6. Name items of information about a valve which are identified by the name plate of that valve.

7. State the general purpose of checking the following during preinstallation inspection:
   a. valve identity
   b. procedures and drawings
   c. prerequisites
   d. valve physical condition
   e. site conditions

8. State the general purpose of checking the following during installation inspection:
   a. control of revisions to procedures and drawings

   b. indication of quality status.

c. compliance with sequence

d. control of nonconformance

e. nondestructive examinations

f. torquing

g. final installation

9. Describe the role of an installation job package.

10. State the purpose of each of the following tests of valves:

a. operability

b. hydrostatic

c. seat leakage

d. stroke time

e. relief set point

f. control system test

11. Name four areas of a valve which are examined for leaks during hydrostatic testing.

12. Briefly describe the performance of check valve functional tests for check valves in pump discharge lines for parallel centrifugal pumps.

13. Briefly describe the performance of a seat leakage test on a stop valve.

14. Briefly describe the performance of a stroke time test of a power actuated valve.

15. Briefly describe the performance of solenoid-pilot actuated relief valve set point test using a thermocouple for temperature measurement in the relief discharge line.

16. Briefly describe the performance of a functional test of a control system which provides for automatic closure of a valve upon system pressure decreasing below 500 psi.

17. Name six sections of a test procedure and generally describe the information provided by each.
a.

b.

c.

d.

e.

f.

MATERIALS

The following valves are suggested for student/trainee use in carrying out the Exercises for this module.

1. Gate Valve
2. Globe Valve
3. Check Valve
4. Plug Valve
5. Butterfly Valve
6. Relief Valve

PROCEDURES

1. Using sample valves of the following types:
   a. Gate Valve
   b. Globe Valve
   c. Check Valve
   d. Plug Valve
   e. Butterfly Valve

   and f. Relief Valve,

   dismantle each valve available.

2. Draw a basic sketch of the construction of each valve in Table 30-3-1.

3. With each sketch, in Table 30-3-2:
   a. State the primary function of each valve.
   b. Give an example of where that particular valve could be used.

4. Re-assemble each valve.

DATA TABLE

Table 30-3-1

Sketch of Valve

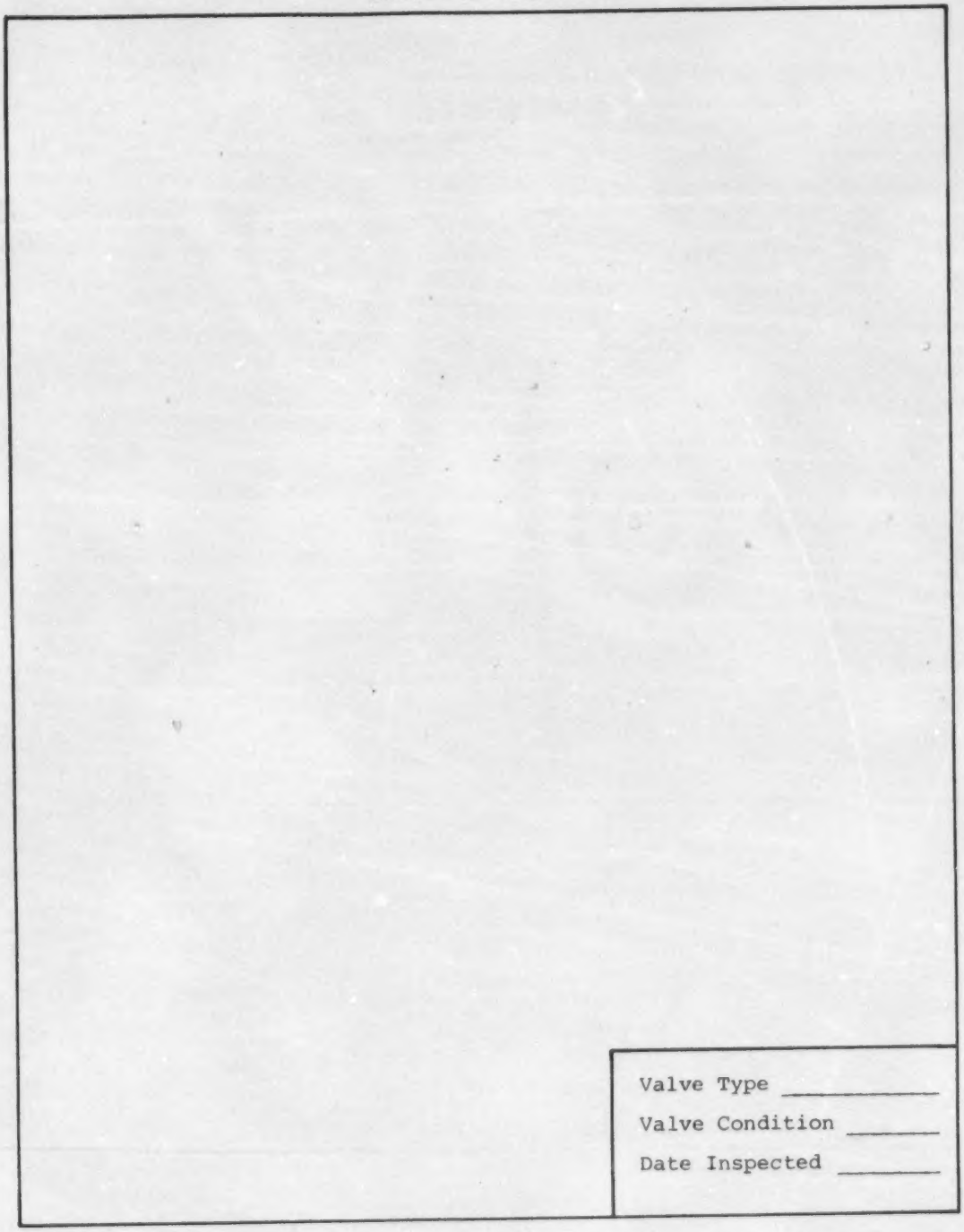


Table 30-3-2

Valve Data

Valve Type	
Valve Condition	
Date Inspected	
Primary Function	
Typical use of this valve	
Remarks	

REFERENCE MATERIALS

ASME, Boiler and Pressure Vessel Code, Section III, The American Society of Mechanical Engineers, New York, N.Y., 1978

ASME, Supplementary Quality Assurance Requirements for Installation, Inspection, and Testing of Mechanical Equipment and Systems for the Construction Phase of Nuclear Power Plants, ANSI - N45.2.8, The American Society of Mechanical Engineers, New York, N.Y., 1975

ASME, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, ANSI N18.7, The American Society of Mechanical Engineers, New York, N.Y., 1976

ASME, Performance Test Code - Safety and Relief Valves, PTC-25.3, The American Society of Mechanical Engineers, New York, N.Y., 1976

Lyons, Jerry L. and Askland, Carl L., Lyon's Encyclopedia of Valves, Van Nostrand Reinhold, 1975

Schweitzer, Philip A., A Handbook of Valves, Industrial Press, 1972

TEST

A. Answer the following questions as either true or false:

____ 1. Pressure boundary parts of valves are bonnet, body, disk, and bonnet-to-body closure mechanism which may be bolts, threaded union, or welded joint.

____ 2. Check valves are used as stop valves due to their low pressure loss when open. They have low seat leakage characteristics although low differential pressure across the disk may result in relatively high seat leakage. They have poor throttling characteristics. Actuators must overcome friction from differential pressure across the disk.

____ 3. Globe valves may be used as stop valves if their relatively high pressure loss when open is not a major concern. They have good throttling characteristics for use in flow regulation. They have very low seat leakage rates. The valve may be arranged where fluid flow aids opening and impedes closing or vice versa.

____ 4. Check valves permit flow from inlet to outlet but not vice versa. Styles include swing check, lift check, and stop lift check. Swing checks have lowest pressure loss when open. Stop lift checks also function as a stop valve. Lift checks and stop lift checks typically have less reverse flow seat leakage than swing checks.

____ 5. Plug valves and ball valves are used as stop valves. They have low pressure loss when open and low seat leakage when closed.

____ 6. Butterfly valves are used as stop vales and throttle valves. They have high pressure loss when open and, provided the resilient seats are in good condition, they have low seat leakage when

closed. They are typically used in high pressure, large piping systems.

____ 7. Relief valves and safety valves provide protection from overpressurization and may be pilot actuated or self actuated. Relief valves are used to protect liquid systems and safety valves are used to protect liquid systems and safety valves are used to protect gas systems. The pressure at which the valve is set point pressure.

____ 8. Steam traps drain condensate from steam lines without discharging steam. Thermostatic traps use either bimetallic actuator or bellows containing volatile liquid actuator. Mechanical traps use either ball or bucket floats as actuators.

____ 9. Types of valve actuators include manual handwheel, manual lever, electric motor, pneumatic, cryogenic, pyrotechnic and piezoelectric.

____ 10. Motor actuators use limit switches to secure power to the motor upon full valve closure or opening.

____ 11. Types of valve indications include local and remote. Local indication is typically by mechanical indicator connected to the stem or actuator gear train. Remote indication is typically by a claxon horn.

____ 12. Preinstallation inspection verifies that:

- Valve identity matches that required by the installation job package.
- Approved procedures and drawings are available.
- Qualified personnel are available, as required.
- Prerequisites are met.
- Necessary handling and fixturing equipment are available.
- Safety requirements are met.
- Valves have not been damaged, do not have unresolved nonconformances, and are adequately clean.

- Installation site conditions are adequate for maintaining valve quality.

____ 13. Valve identity is provided by its nameplate which identifies (1) valve manufacturer, (2) types of valve, (3) design pressure and temperature, (4) code classification, (5) valve serial number, and (6) national board number.

____ 14. Installation inspection verifies that:

- Revisions of procedures and drawings are provided to the installation site as appropriate.
- Qualified personnel and approved materials and procedures are used.
- Quality status indication is maintained.
- Specified sequences are met.
- Nonconformances are corrected.
- Required as-built dimensions are recorded.
- Required inspections and tests are performed.
- Required nondestructive examinations are performed.
- Installation work complies with procedural and drawing requirements including those for orientation, torquing, cleaning, welding, pipe fitting, housekeeping, and protection of valve internals.
- All steps of the installation job package have been completed.
- Limit switches, interlocks and stops are installed as required.
- All specified mounts, hangers, and supports are installed as required.
- All specified temporary protective plugs, covers, and strainers are installed.

____ 15. The installation job package contains sequential instructions for installing valves, welding instructions, packing repair procedures and non-destructive examination techniques for the valve.

____ 16. Valve operability tests are performed as one of the final steps of installation. They verify full valve operation by its actuator opening the valve within 3.5 seconds.

____ 17. Hydrostatic tests verify that maximum leakage requirements of installed systems, including valves, are met. Hydrostatic tests are performed by filling and venting the system with water, raising water pressure to test pressure, and visually examining exterior surfaces for leaks. Valve areas examined are stem packing, bonnet-to-body joint, body-to-pipe joints, and external surfaces of the bonnet and body. These tests normally take place at seventeen (17) times the rated system pressure.

____ 18. Check valve functional tests verify that reverse flow does not occur. These tests are performed by establishing a higher pressure on the check valve outlet and observing for reverse flow.

____ 19. Seat leakage tests verify complaince with specified maximum seat leak rates. These tests are performed by establishing a specified differential pressure across the closed valve, collecting leakage for a timed interval, and calculating leak rate.

____ 20. Stroke time tests verify that time of full valve travel is within specified limits. These tests are performed by operating the valve by its normal actuator and measuring the time of full travel to be less than or equal to 3.5 seconds.

____ 21. Relief and safety set point tests verify that relief valves and safety valves open within a specified range of pressure. These tests are performed by actuating the pilot of pilot-operated reliefs and on test stands for self-actuated relief and safety valves.

____ 22. Open-close control system tests verify that controlled valves either open or close as designed at specified values of plant parameters. These tests are performed by simulating plant parameters and observing the value at which the value actuates.

____ 23. Variable position control system tests verify that controlled valves position proportionally to values of plant parameters. These tests are performed by simulating plant parameters and observing for specified positioning of the valve.

____ 24. Written test procedures govern conduct of tests. Each test procedure contains (1) title, number, and revision, (2) test objectives, (3) test equipment, (4) prerequisites, (5) limitations, (6) procedure, notes, and cautions, and (7) acceptance criteria.

____ 25. In the flexible wedge of a parallel disk gate valve, seat leakage is typically lowest when the differential pressure across the closed value is lowest.

B. Answer the following questions as indicated:

1. State the primary functions of:
   a. gate valves
   b. globe vlaves
   c. check valves
   d. plug valves
   e. butterfly valves
   f. relief valves

2. In the flexible wedge of parallel disk gate valve, seat leakage is typically highest when differential pressure across the closed valve is lowest. Explain how this occurs.

3. Describe the operation of a self-actuated, spring loaded relief valve.

4. State the purpose and describe the operation of a bucket type steam trap.

5. Briefly describe the operation of the following valve actuators.
   a. Hammer handwheel

   b. Motor

   c. Single solenoid

6. Name the type of valve represented by:

a.

b.

c.

d.

7. Name items of information about a valve which are identified by the name plate of that valve.

8. Describe the role of an installation job package.

9. State the purpose of each of the following tests of valves.

a. operability

b. hydrostatic

c. seat leakage

d. stroke time

e. relief set point

f. control system test

10. Name four areas of a valve which are examined for leaks during hydrostatic testing.

11. Name six sections of a test procedure and generally describe the information provided by each.

a.

b.

c.

d.

e.

f.